O'Shaughnessy Dam and Reservoir

Features of Its Design and Construction

By EDWARD M. SEVCIK, '30.

The O'Shaughnessy Dam, one of the finest in this section of the country, was built to increase the storage of raw water for the water supply of Columbus. The masonry portion of the dam is of the overflow gravity type, the spillway section, 879 ft. in length between end abutments, being spanned by a twelve-arch reinforced concrete bridge. The crest of the spillway is 64 ft. above low water in the river and has a discharge capacity of 110,000 cu. ft. per second. The reservoir, formed by the construction of the dam, is eight miles in length, has a maximum width of 1,900 ft., and a total available storage capacity of 5,341,000,000 gallons. The total cost of the dam and reservoir was $2,220,080. It was named in honor of the late Jerry O'Shaughnessy, who served as the superintendent of the Columbus Waterworks for many years.

What follows has been abstracted from the paper "The O'Shaughnessy Dam and Reservoir," which was presented recently at a meeting of the American Society of Civil Engineers, by John H. Gregory, professor of Civil and Sanitary Engineering, the Johns Hopkins University, Baltimore, Md. The paper was prepared by Professor Gregory, C. B. Hoover, and C. B. Cornell:

In 1926 the city of Columbus had an estimated population of 285,000. The water consumption was 27,400,000 gallons daily including water supplied to a population of 15,200 outside the city limits. With an estimated water consumption of 110 gallons per capita daily, the source of supply, the O'Shaughnessy Dam, together with the Griggs Dam, will now provide for a population of 500,000, estimated to be reached somewhere between 1950 and 1955.

At the Julian Griggs Dam the Scioto river has a watershed of 1,052 square miles, and at the O'Shaughnessy Dam, 988 square miles. On the watershed the rock is of limestone formation and is exposed at many places. Where the rock is covered the drift is of varying thickness. The water is hard and is unsatisfactory for domestic and industrial uses unless softened. The average total hardness is 272 parts per million. The water is softened and filtered before delivery into the distribution system.

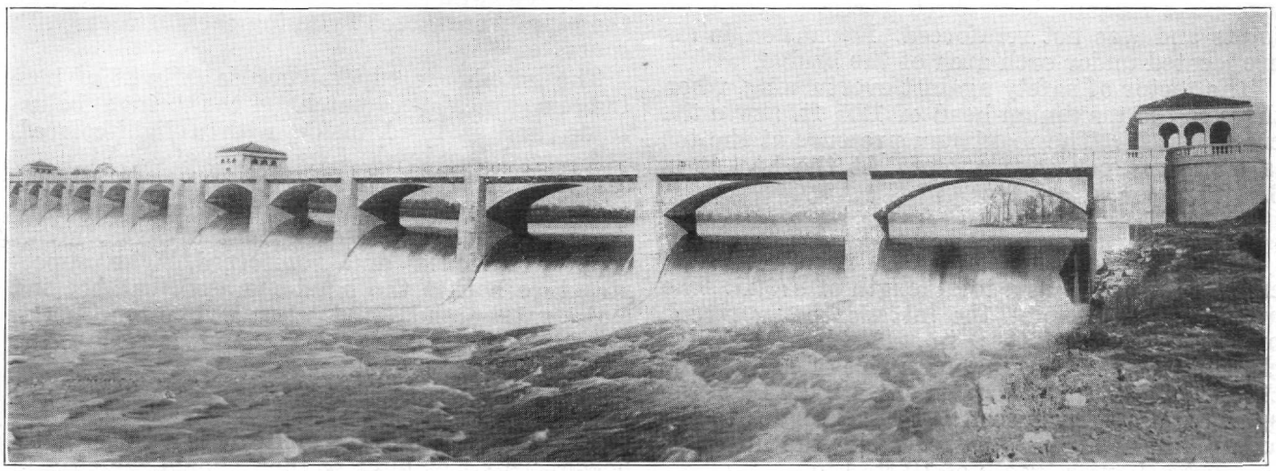
Type of Structure

The O'Shaughnessy Dam is a concrete masonry dam, of the gravity overflow type, straight in plan and 1,750 ft. in length, including the approaches. The masonry portion of the dam is 879 ft. long, measured face to face of the copings on the abutments. The two approaches have a total length of 871 ft., but they are not equal, the east approach being slightly longer than the west one.

Crossing the dam, above the overflow or spillway section is a reinforced concrete arch bridge of twelve spans, each span measuring 64 ft. 6 in. in the clear. The net length of the spillway, under the bridge, after deducting the length of the bridge piers and the outlet gate-house is 765.7 ft.

The crest of the spillway is 64 ft. above low water in the river on the down-stream side of the dam and 84 ft. above the rock foundation. The roadway on the bridge is 21.3 ft. above the crest of the spillway, making a total height of dam from rock foundation to roadway level of 105.3 ft. The spillway capacity of the dam is 110,000 cu. ft. per second, or about 50 per cent in excess of the 1913 flood. This would require a head of 12.5 ft.

The site of the dam was selected after more than a year of preliminary surveys and studies. This site is about sixteen miles north of the center of the city. Twenty-two diamond drill borings were made. Deep holes were drilled under the body of the dam, near the water's edge, on the east bank of the river; at the top of the deep slopes on the banks; and at the center of the river.



Up-stream View of the O'Shaughnessy Dam

Geology of the Site

From a point 4.5 miles below the Griggs Dam to a point well above the limits of the backwater from the O'Shaughnessy Dam, the Scioto river flows through a valley cut in the Devonian limestone. Overlying the limestone, at all points in the valley where the slopes are flat enough to prevent erosion, is a mantle of Wisconsin glacial drift, consisting very largely of yellow boulder clay with a thin top layer of clay loam, the boulder clay being an ideal material for embankments and the loam suitable for top dressing.

Throughout the Columbus District, the Columbus limestone has an average thickness of about 105 ft. The Delaware limestone lies above the Columbus limestone, the contact being characterized by the bone-bed, notable among geologists for its high content of fossilized plates, teeth and other bony structures of Devonian fish life. Below the Columbus limestone, the Munroe limestone is encountered, the two being separated, however, by an unconformable layer of variable thickness known as the basal conglomerate which consists of pebbles of Munroe limestone embedded in a matrix of smaller Columbus pebbles and quartz sand.

The Columbus formation consists of a massive basal layer, known at the local quarries as the "Six-Foot Stone," surmounted by many layers of varying thickness ranging from two or three inches to four and five feet and varying in chemical composition from a true dolomite to an almost pure calcite, with physical characteristics almost as variable as the chemical composition. The dip of the rock is from 20 to 30 ft. per mile to the east or a little south of east.

Design of the Spillway Section

In the design of the spillway section, the following assumptions were made:

Weight of masonry in pounds per cubic foot	145
Ice thrust acting at crest, in pounds per linear foot	20,000
Upward pressure: Full head pressure at heel decreasing uniformly to 0 at the toe, acting over two-thirds of the area.	

Steel reinforcement was provided at the back of the dam at each horizontal construction joint in the top 40 ft. The upper 10 ft. of the spillway was built monolithic between vertical expansion joints and was not reinforced. Expansion joints are located under each arch of the bridge.

The factor of safety against overturning, when there is the maximum head of 12.5 ft. above the crest, is 2.25. The maximum pressure at the toe is 5.82 tons per square foot. At the heel it is 6.92 tons per square foot.

Reinforced Concrete Arch Bridge Over Spillway

The bridge consists of twelve reinforced concrete arches and has a total length of 879 ft. The arches are segmental, the intrados being struck on a radius of 52 ft. 9 in.. Each arch has a clear span of 64 ft. 6 in. and a rise of 11 ft. The thickness at the crown is 18 in. and at the springing line three feet. At right angles to the axis of the bridge, measured along the intrados, the arches have a length of 19 ft. 4 in.

The roadway over the arches has a clear width of 17 ft. 6 in., and is carried by reinforced concrete slabs supported by a spandrel and curtain-walls extending down the arch rings, except that, for a length of 21 ft. 6 in. at the center of each arch, the concrete slabs are supported on a cinder fill made directly over the arch rings. The roadway surface is a vitrified brick pavement, four inches thick, laid on a one-inch sand-cushion. The joints in the brick are grouted with an asphalt filler.

The roadway is drained by cast-iron inlets spaced at frequent intervals along each side of the pavement. The storm water is collected above the arches and is discharged through the arches, or through the piers, depending on the arrangement of the details.

On each side of the roadway is a four-foot sidewalk, consisting of a reinforced concrete slab carried on a cantilever bracket anchored to the arch ring at the center of the arch and to the spandrel walls over the haunches at other points. The balustrade on each sidewalk, together with the pylons, is constructed of blue Indiana limestone.

Approaches

At each end of the spillway section the approach consists of a rolled earth embankment or dike with concrete core wall. The approaches are 25 ft. 6 in. wide on top and have side slopes of one or two. The concrete core wall is three feet wide and about nine feet high, and is keyed 12 in. into solid rock.

Outlet Gate-House

The outlet gate-house is 32 ft. square, inside dimensions, and is located at the center of the spillway, projecting out from the upstream side of the dam. When the water is drained from storage it is taken through the gate-chamber immediately below. In the gate chamber are two sets of chambers or wells, each set consisting of two separate wells connected by sluice-gates. There is no connection between the two sets of wells, thus providing duplicate means of drawing water from the reservoir. In case of repair to any sluice-gate one set of wells can be shut off. At the bottom of the gate chamber, four 48-inch cast-iron pipes were placed. These pipes took the ordinary flow of the river after the dam and gate-chamber had been constructed to an elevation above low water. After completion of the dam the pipes were closed by filling each of them with concrete.

The gate-house superstructure is built of blue Indiana limestone, matching the bridge balustrade, and is lined inside with a light-colored, salt-glazed face brick. The roof is of steel trusses carrying a three-inch concrete slab, and covered with bright red mission tile. The doors and windows are of hollow metal, built of hard, heavy copper, stiffened and reinforced. The superstructure houses the hand-operated, ball-bearing sluice-gate stands and also a two-ton, hand-operated crane for raising and lowering the screens and stop-planks.

Power Gate-House

At the west end of the spillway is a power gate-house. This was built so that, should the city, in

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the future, wish to develop power at certain times of the year, that is, with reservoir full and water overflowing the spillway, or when water is drawn from storage, say, from the upper 10 or 15-foot depth in the reservoir, it could do so by constructing a hydro-electric power plant below the dam, on the west side of the river. The power gate-house is slightly smaller in size than, but of the same construction as, the outlet gate-house; it contains no equipment at present.

Pavilion

To balance the structure as a whole, a pavilion has been built at the east end of the spillway. It is similar in construction and dimensions to the power gate-house, except that the wall panels between the pilasters have been omitted on all four sides. In the three sides other than that next to the roadway, balustrades, similar to those on the bridge, have been built, both for protection and for architectural effect. From the pavilion a commanding view is obtained, especially up stream across the reservoir.

Spillway Channels

With the width of spillway adopted it was necessary to provide spillway channels below the dam on each side of the river. This was accomplished by excavating benches in the rock, the benches being curved in plan and sloping down stream from the toe of the apron until the river bank is reached. These benches vary in width from a minimum of 32 ft. 11 in. to a maximum of 103 ft. 3 in., and in height from a minimum of 5 ft. to a maximum of 20 ft. In excavating these

spillway channels a double purpose was served; not only do they provide for guiding flood-water down to the river, but they also furnished most of the rock for the construction of the dam. With water passing over the spillway of the dam it flows along these benches and, at the same time, spills over from one bench to the next lower one until it reaches the river. The greater the flow the longer the travel of the water along the benches.

Construction Plant

A construction plant, more or less elaborate, was required for building the dam. Practically all the equipment was electrically operated. For constructing the masonry part of the dam two traveling cableways were installed. Trucks were used for hauling all the equipment and building materials from the railroad spur at Powell, Ohio, three miles away. The bulk of the excavation, both earth and rock, was made with a one-yard Osgood steam shovel, mounted on a caterpillar truck. Practically all the concrete was mixed at a central mixing plant located about 100 feet upstream from the dam and on the east side. The aggregates were proportioned by volume.

Coffer-Dams

The dewatering of the coffer-dams was done by two 4-inch discharge, motor-driven, low-lift pumps. When once pumped down, the intermittent operation of one pump would handle the leakage. The first coffer-dam was built around the region of the gate-house. The sides of the coffer-dams were cribs, about 10 ft. wide, made of small logs secured on the site of the work, the framing being done on the bank of the river. When complete, the cribs were skidded into the river, floated into position, fastened together, and sunk by filling them with rock. Earth was then placed around the outside of the coffer-dam, after which two-inch sheeting was placed, edge to edge, all the way around the outside face of the cribbing.

Excavation and Foundation Grouting

A considerable amount of hand excavation was necessary in trimming the area of the dam and apron and the spillway channels. Throughout the work it was necessary to drill and blast the rock before it could be handled by steam shovel, and wherever the excavation had to be brought to neat lines, it was necessary to line drill the rock before blasting to prevent overbreaks. A number of crevices were opened in the bed rock by the excavation. Each crevice was cleaned out with water under pressure and then filled with grout. This was done in order to block every possible channel through which water might seep through under the dam. A total of 553 grout holes were drilled under the dam, abutments, and core walls. They ranged from 4.1 to 11.1 ft. in depth.

Concrete

Five classes of concrete were used. The total volume of concrete placed was 79,565 cubic yards, at an average price of $9.29 per cubic yard. The fine aggregate used was a washed bank sand shipped from Dresden, Ohio, 55 miles east of Columbus. The coarse aggregate was crushed limestone obtained mainly from the rock excavation for the dam and spillway channels. The main body of the dam was of 1:3:6 concrete. About 93,500 barrels of Portland cement was used, making the ratio of cement to concrete 1.18 barrels of cement per cubic yard of concrete.

Clearing and Grubbing

Notwithstanding the fact that the water is purified by filtration, it was considered advisable to grub as well as to clear the reservoir site. This was done over the whole of the area flooded and up to an elevation of two feet above normal water surface. The total area cleared and grubbed was 741 acres. All trees, saplings, and brush were cut down flush with the surface of the ground, and all stumps and roots larger than two inches in diameter were removed to a depth of at least six inches below the surface of the ground.